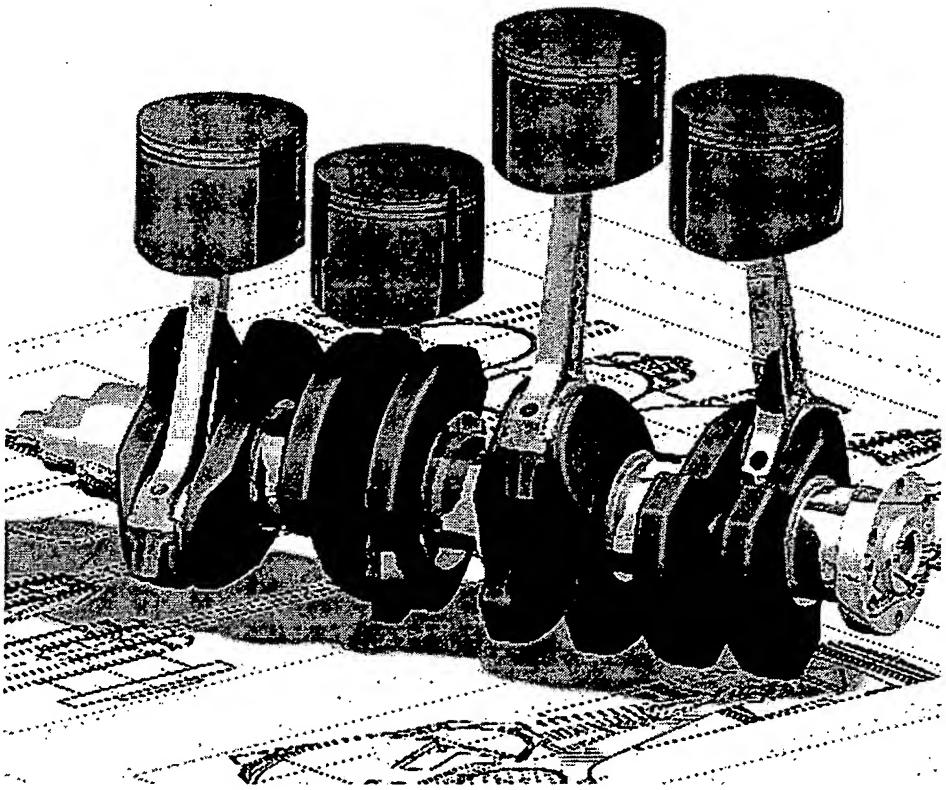
Computer-aided design

From Wikipedia, the free encyclopedia
(Redirected from Computer aided design)

Computer-aided design (CAD) is the use of a wide range of computer-based tools that assist engineers, architects and other design professionals in their design activities. It is the main geometry authoring tool within the Product Lifecycle Management process and involves both software and sometimes special-purpose hardware. Current packages range from 2D vector based drafting systems to 3D parametric surface and solid design modellers.

CAD is sometimes translated as "computer-assisted", "computer-aided drafting", or a similar phrase. Related acronyms are CADD, which stands for "computer-aided design and drafting", CAID for Computer-aided Industrial Design and CAAD, for "computer-aided architectural design". All these terms are essentially synonymous, but there are some subtle differences in meaning and application.

CADD stands for Computer Aided Drafting and Design.



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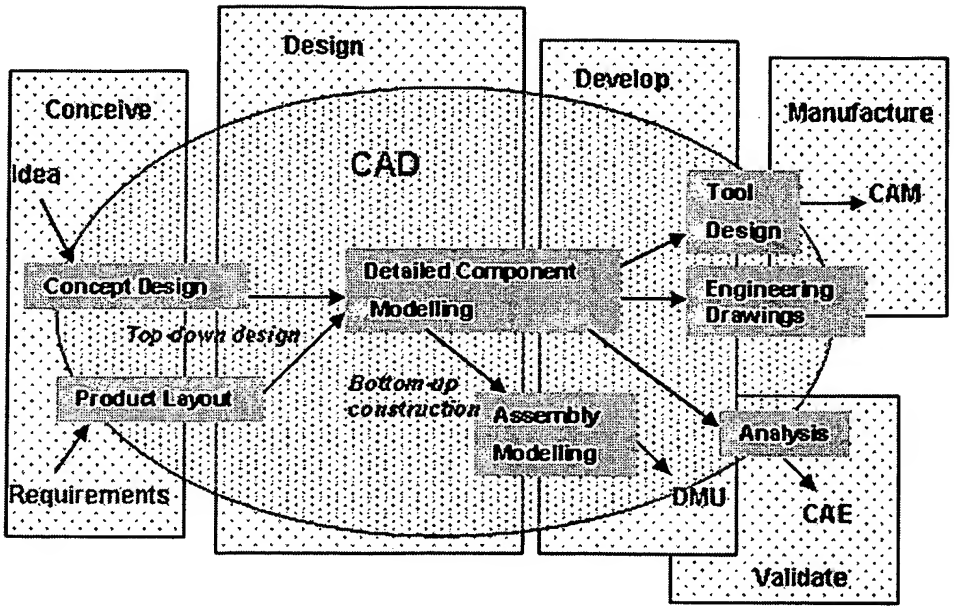
Introduction

CAD is used to design and develop products, which can be goods used by end consumers or intermediate goods used in other products. CAD is also extensively used in the design of tools and machinery used in the manufacture of components. CAD is also used in the drafting and design of all types of buildings, from small residential types (houses) to the largest commercial and industrial types (hospitals and factories).

CAD is used throughout the engineering process from conceptual design and layout, through detailed engineering and analysis of components to definition of manufacturing methods.

Fields of use

- Architecture, Industrial Design, Engineering, Garden design and Construction - the "AEC industry"
- Building engineering
- Civil Engineering and Infrastructure
  - Roads and Highways
  - Water and Sewer systems
  - Mapping and Surveying
- Mechanical (MCAD)
  - Automotive
  - Aerospace
  - Consumer Goods
  - Machinery
  - Ship Building
- Electronic and Electrical (ECAD)
- Manufacturing process planning
- Digital circuit design
- Software applications
- Apparel and Textile CAD
- Fashion Design



Architecture

The software package may produce its results in several formats, but typically provides a graphically-based result which is then able to be used to create concept sketches for assessment and approval, and eventually working drawings. An example would be a structural design package used to assess the integrity of a steel-framed building by performing all the calculations necessary to determine the size, strength, the placement of the components, and the effect of such things as wind-loading. The output commonly is a schedule of materials and some basic sketches which can be transferred to a CAD software package for final production of construction drawings.

Computer-aided drafting, commonly refers to the actual technical drawing component of the project, using a computer rather than a traditional drawing board. The input into this aspect of the design process may come from specialised calculation packages, from pre-existing component drawings, from graphical images such as maps, from photos and other media, or simply from hand-drawn sketches done by the designer. The operator's task is to use the CAD software to meld all the relevant components together to produce drawings and specifications which can then be used to estimate quantities of materials, determine the cost of the project and ultimately provide the detailed drawings necessary to build it.

The spectrum of architectural and engineering projects commonly documented with computer-aided drafting is broad, and includes architectural, mechanical, electrical, structural, hydraulic, interior design, garden design, civil construction. CAD may also provide input to other forms of design communication such as 3D visualisations, model construction, animated fly-throughs, to name a few.

Computer-aided drafting software is also a basic tool used in other disciplines related to Architecture, for example Civil Engineering, for site design, for instance roads, grading and drainage, in mapping and cartography, in the production of plans and sketches for a variety of other purposes (such surveyor's plans and legal descriptions of land), and as the input format to geographic and facilities information systems. Additionally, landscape architecture and interior design is also commonly performed using CAD software.

Software applications

Computer-aided design software is also starting to be used to develop software applications. Software applications share many of the same Product Life Cycle attributes as the manufacturing or electronic markets. As computer software becomes more complicated and harder to update and change, it is becoming essential to develop interactive prototypes or simulations of the software before doing any coding. The benefit of simulation before writing actual code is significantly less time spent on re-writing code due to Software bugs.

History

Designers have long used computers for their calculations. Initial developments were carried out in the 1960s within the aircraft and automotive industries in the area of 3D surface construction and NC programming, most of it independent of one another and often not publicly published until much later. Some of the mathematical description work on curves was developed in the early 1940s by Isaac Jacob Schoenberg, Apalatequi (Douglas Aircraft) and Roy Liming (North American Aircraft), however probably the most important work on polynomial curves and sculptured surface was done by Pierre Bezier (Renault), Paul de Casteljau (Citroen), Steven Anson Coons (MIT, Ford), James Ferguson (Boeing), Carl de Boor (GM), Birkhoff (GM) and Garabedian (GM) in the 1960s and W. Gordon (GM) and R. Riesenfeld in the 1970s.

It is argued that a turning point was the development of SKETCHPAD system in MIT in 1963 by Ivan Sutherland (who later created a graphics technology company with Dr. David Evans). The distinctive feature of SKETCHPAD was that it allowed the designer to interact with computer graphically: the design can be fed into the computer by drawing on a CRT monitor with a light pen. Effectively, it was a prototype of graphical user interface, an indispensable feature of modern CAD.

First commercial applications of CAD were in large companies in the automotive and aerospace industries, as well as in electronics. Only large corporations could afford the computers capable of performing the calculations. Notable company projects were at GM (Dr. Patrick J.Hanratty) with DAC-1 (Design Augmented by Computer) 1964; Lockhead projects; Bell GRAPHIC 1 and at Renault (Bezier) – UNISURF 1971 car body design and tooling.

The most influential event in the development of CAD was the founding of MCS (Manufacturing and Consulting Services Inc.) in 1971 by Dr. P. J. Hanratty, who wrote the system ADAM (Automated Drafting And Machining) but more importantly supplied code to companies such as McDonnell Douglas (Unigraphics), Computervision (CADDS), Calma, Gerber, Autotrol and Control Data.

As computers became more affordable, the application areas have gradually expanded. The development of CAD software for personal desk-top computers was the impetus for almost universal application in all areas of construction.

Other key points in the 1960s and 1970s would be the foundation of CAD systems United Computing, Intergraph, IBM, Intergraph IGDS in 1974 (which led to Bentley MicroStation in 1984)

CAD implementations have evolved dramatically since then. Initially, with 2D in the 1970s, it was typically limited to producing drawings similar to hand-drafted drawings. Advances in programming and computer hardware, notably solid modelling in the 1980s, have allowed more versatile applications of computers in design activities. Key product for 1981 were the solid modelling packages - Romulus (ShapeData) and Uni-Solid (Unigraphics) based on PADL-2 and the release of the surface modeler CATIA (Dassault Systemes). Autodesk was founded 1982 by John Walker, which led to the 2D system AutoCAD. The next milestone was the release of Pro/Engineer in 1988, which heralded greater usage of feature based modeling methods. Also of importance to the development of CAD was the development of the B-rep solid modeling kernels (graphics engines) Parasolid (ShapeData) and ACIS (Spatial Technology Inc.) at the end of the 1980s beginning of the 1990s, both inspired by the work of Ian Braid. This led to the release of mid-range packages such as SolidWorks in 1995 SolidEdge (Intergraph) in 1996 and IronCAD in 1998.

Today CAD is not limited to drafting and rendering, and it ventures into many more "intellectual" areas of a designer's expertise. Computer aided design is used in many businesses and organizations around the world.

Software providers today

This is an ever changing industry with many well known products and companies being taken over and merged with others. There are many CAD software products currently on the market. More than half of the market is however covered by the five main PLM corporations Autodesk, Dassault Systemes, PTC, UGS Corp., and VISTAGY, Inc., but there are many other CAD packages with smaller user bases or covering niche user areas.

Packages can be classified into three types: 2D drafting systems (e.g. AutoCAD, Microstation); mid-range 3D solid feature modellers (e.g. IronCAD, SolidWorks, SolidEdge, Alibre Design); and high-end 3D hybrid systems (e.g. Pro/ENGINEER, CATIA, NX (Unigraphics)). However these classifications cannot be applied too strictly as many 2D systems have 3D modules, the mid-range systems are increasing their surface functionality, and the high-end systems have developed their user interface in the direction of interactive Windows systems.

Capabilities

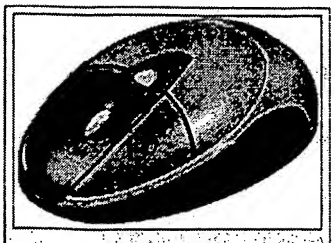
The capabilities of modern CAD systems include:

- Wireframe geometry creation
- 3D parametric feature based modelling, Solid modelling
- Freeform surface modelling
- Automated design of assemblies, which are collections of parts and/or other assemblies
- create Engineering drawings from the solid models
- Reuse of design components
- Ease of modification of design of model and the production of multiple versions
- Automatic generation of standard components of the design
- Validation/verification of designs against specifications and design rules
- Simulation of designs without building a physical prototype
- Output of engineering documentation, such as manufacturing drawings, and Bills of Materials to reflect the BOM required to build the product
- Import/Export routines to exchange data with other software packages
- Output of design data directly to manufacturing facilities
- Output directly to a Rapid Prototyping or Rapid Manufacture Machine for industrial prototypes
- maintain libraries of parts and assemblies
- calculate mass properties of parts and assemblies
- aid visualization with shading, rotating, hidden line removal, etc...
- Bi-directional parametric associatively (modification of any feature is reflected in all information relying on that feature; drawings, mass properties, assemblies, etc... and counter wise)
- kinematics, interference and clearance checking of assemblies
- sheet metal
- hose/cable routing
- electrical component packaging
- inclusion of programming code in a model to control and relate desired attributes of the model
- Programmable design studies and optimization
- Sophisticated visual analysis routines, for draft, curvature, curvature continuity...

Software technologies

Originally software for CAD systems were developed with computer language such as Fortran, but with the advancement of object-oriented programming methods this has radically changed. The development of a typical modern parametric feature based modeler and freeform surface systems are built around a number of key, C programming language, modules with their own APIs. A CAD system can be seen as built up from the interaction a graphical user NURBS geometry via a geometric modeling kernel.

Hardware and OS technologies

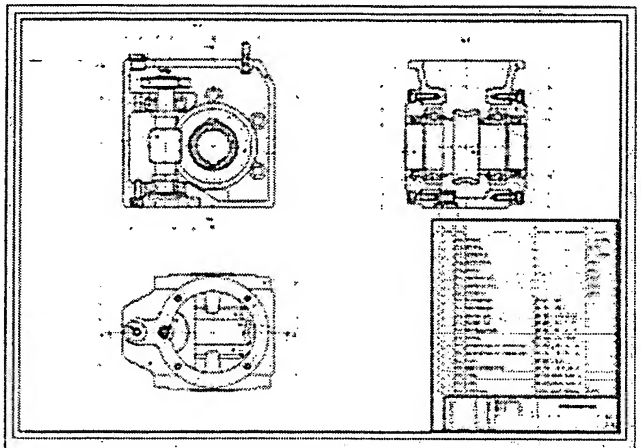

A CAD model of a mouse

Today most CAD computer workstations are Windows based PCs; some CAD systems also run on l the Unix operating systems and a few with Linux. Generally no special hardware is required with th OpenGL based Graphics card; however for complex product design, machines with high speed (and large amounts of RAM are recommended. The human-machine interface is generally via a computer pen and digitizing graphics tablet. Manipulation of the view of the model on the screen is also some spacemouse/spaceball. Some systems also support stereoscopic glasses for viewing the 3D model.

The CAD operator

Each of the different types of CAD systems requires the operator to think differently about how he will use them and he must design his virtual components in a different manner for each.

There are many producers of the lower end 2D systems, including a number of free and open source programs. These provide an approach to the drawing process without all the fuss over scale and placement on the drawing sheet that accompanied hand drafting, since these can be adjusted as required during the creation of the final draft.


An example of a CAD engineering drawing

3D wireframe is basically an extension of 2D drafting. Each line has to be manually inserted into the drawing. The final product has no mass properties associated with it and cannot have features directly added to it (ex., holes). The operator approaches these in a similar fashion to the 2D systems, although many 3D systems allow you to use the wireframe model to make the final engineering drawing views.

3D "dumb" solids (programs incorporating this technology include AutoCAD 2000(Latest CAD version in market is AutoCAD 2007) and Cadkey 19) are created in a very similar fashion to the way you would create the real world object. Each object and feature, after creation, is what it is. If the operator wants to change it, he has to add "material" to it, subtract it from it, or delete the object or feature and start over. Due to this, it doesn't matter how the initial operator creates his components, as long as the final product is represented correctly. If future modifications are to be made, the method used to make the original part will not, in most cases, affect the procedure used to make the new modifications. Draft views are able to be generated easily from the models. Assemblies generally don't include tools to easily allow motion of components, set limits to their motion, or identify interference between components.

3D parametric solids (programs incorporating this technology include IronCAD, Alibre, SolidWorks, and Solid Edge) require the operator to use what is referred to as "design intent". The objects and features created are adjustable. Any future modifications will be simple, difficult, or nearly impossible, depending on how the original part was created. One must think of this as being a "perfect world" representation of the component. If a feature was intended to be located off of the center of the part, the operator needs to locate it off of the center of the model, not, perhaps, off of a more convenient edge or an arbitrary point, as he could when using "dumb" solids. Parametric solids require the operator to consider the consequences of his actions carefully. What may be simplest today could be worst case tomorrow. Draft views are able to be generated easily from the models. Assemblies usually incorporate tools to represent the motions of components, set their limits, and identify interference. The tool kits available for these systems are ever increasing, including 3D piping and injection mold designing packages.

Mid range software was integrating parametric solids more easily to the end user: integrating more intuitive functions (SketchUp), going to the best of both worlds with 3D dumb solids with parametric characteristics (VectorWorks) or making very real-view

scenes in relative few steps (Cinema4D).

Top end systems (such as Pro/ENGINEER and CATIA) offer the capabilities to incorporate more organic and ergonomic features into your designs. Surfaces are often combined with solids to allow the designer to create products that fit the human form as well as they interface with the machine.

The CAD operator's ultimate goal should be to make future work on the current project as simple as possible. This requires a solid understanding of the system being used. A little extra time spent now could mean a great savings later.

Backronyms

- Computer-aided drafting

See also

CAD is one part of the whole Digital Product Development (DPD) activity within the Product Lifecycle Management (PLM) process, and as such is used together with other tools, which are either integrated modules or stand-alone products. These include:

- Computer-Aided Engineering (CAE) and Finite Element Analysis (FEA)
- Computer-Aided Manufacturing (CAM) including instructions to Computer Numerical Control CNC machines
- Computer-aided garden design
- Photo realistic rendering
- Document management and revision control using Product Data Management (PDM).

Other related topics

- Building Information Modeling
- Raster to vector
- Computer graphics
- Computer representation of surfaces
- List of CAD companies
- CAD standards
  - ISO 13567
  - UniClass
- New product development
- Category:Computer-aided design software
- Category:Computer-aided manufacturing software
- Category:Computer-aided engineering software
- Category:Free computer-aided design software
- Category:CAD file formats

External links

- Computer-aided design (http://dmoz.org/Computers/CAD_and_CAM) at the Open Directory Project
- CADLearning. The Tutorial resource for Autodesk users. (http://www.cadlearning.com/)
- CAD Newsgroups (http://www.electronicspoint.com/f4-cad.html)

Category: Computer-aided design